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Sympathy for the Devil: Conserving Tasmanian Devils in the Face of a Devastating Disease

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SYMPATHY FOR THE DEVIL: CONSERVING TASMANIAN DEVILS IN THE FACE OF A DEVASTATING DISEASE

by

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ABSTRACT:

Devil Facial Tumor Disease (DFTD) is a highly transmissible cancerous disease that has contributed to a rapid decline in Tasmanian devil (*Sarcophilus harrisii*) populations since the first documented case in 1996 (12, 14). Tasmanian devils are social animals and the disease, thought to be spread through facial bites, is highly contagious (5, 10, 11). The disease results in large facial tumors near the mouth. Devils die within three months of diagnosis. Devils' now shortened average lifespans and decreasing populations are not only problematic for the devils themselves, but also for the Tasmanian ecosystem as a whole (6). Questions about DFTD's epidemiology, namely its latency and transmission, remain and, as time runs out for the devils, researchers are searching for a way to slow the species' decline and conserve the existing populations. This thesis explores the various proposals for disease eradication, inoculation, culling, and assurance colonies through a literature review. With this knowledge, the thesis proposes a plan for combating DFTD and conserving Tasmanian devil populations.

INTRODUCTION:

Tasmanian devils and their ecological importance

The Tasmanian devil (*Sarcophilus harrisii*) is the largest marsupial carnivore in the world since the extinction of the Tasmanian tiger (*Thylacinus cynocephalus*) in 1936 [12]. Thousands of years ago, the Tasmanian devil was a prominent figure in several Dreaming stories (a series of creation mythologies, for lack of a better term) of the Aboriginals of Australia [12]. Since then, the devil has been a source of international interest and has become Tasmania's de-facto mascot. While the devil is an intriguing subject in its own right, for the purposes of this research it is important to note the role that the species plays in Tasmanian ecology.

Apex predators like the Tasmanian devil play a significant role in ecosystem regulation by controlling populations of mesopredators and prey species [6, 12]. The arrival of DFTD and the subsequent decline of Tasmanian devils led to a control release on feral cats in Tasmania. As the feral cat population increased, the eastern quoll (*Dasyurus vivverinus*), another mesopredator, experienced a decline due to increased resource competition [6, 7, 12]. Though not mentioned in the literature included in this thesis, one may also assume that the release on the devils' main prey species, the pademelon (*Thylogale billardierii*) could also have adverse effects. Pademelons are small, herbivorous kangaroo-like animals. If the pademelon population were to rise due to the lack of control by Tasmanian devils, they could end up putting too much demand on Tasmania's flora. Maintaining healthy populations of devils in Tasmania is crucial in preventing further adverse trophic cascades.

Devil Facial Tumor Disease

DFTD is a highly transmissible cancerous disease that has been affecting Tasmanian devils since at least 1996, when researchers first documented an infected devil [12, 14]. Starting in the northeast corner of Tasmania, DFTD spread down the east coast, then across the island until it reached the west coast (Fig. 1). The rapid spread of the disease over the following twenty years has lead to an exponential decline in the Tasmanian devil population, which is already limited to Tasmania, an island off the southern coast of mainland Australia. Studies have shown that the disease had lead to a 60% decline in the devil population by 2009 [(5)]. It is now estimated that only 10,000 to 25,0000 devils exist in the wild, and the disease range is believed to encompass the entire Tasmanian devil population range, though some research suggests that a population in the northwest of Tasmania is still disease-free [(5, 10, 11)].

It is widely believed that Tasmanian Devils transmit DFTD to one another through bites. As devils are fairly social animals that bite when fighting, as well as when mating, the disease spreads in the devil population much like sexually transmitted diseases in other animal populations [(4, 10)]. DFTD presents with large facial tumors that grow around the devil's mouth (Fig. 2, 3). The tumors grow so large in size that they impede brain function and eventually make it impossible for infected devils to eat. Once diagnosed, devils live for only three months before starving to death or otherwise succumbing to major brain injuries [(4, 11)].

Devils' usual mating routines have adjusted to accommodate for their recently shortened lifespans, moving the average time of first births from two years old to one year old [(11, 12)]. Because male devils die shortly after mating regardless of their health, DFTD shortens the average devil life expectancy indirectly as well. Early births and deaths have skewed the usual population age demographics.

Since 1996, DFTD has been a devastating force that has threatened the devil population and the ecosystem that depends on the species. Devils should be conserved because they are a necessary ecological component, not to mention that they are organisms with an intrinsic right to exist. Since its first documentation twenty years ago, DFTD has caused a stir in the conservation ecology community. Researchers have proposed dozens of management methods, but have met roadblocks in applying them due to inconsistent funding by the Australian government and lack of knowledge about several key factors of DFTD's pathology.

MATERIALS AND METHODS:

This thesis systematically reviews the existing scientific literature on DFTD and disease management options to identify and evaluate proposed strategies for DFTD control.Literature included herein has been collected from University of Nebraska- Lincoln's libraries website, specifically the Academic Search Premier and GreenFile databases. The search terms used were: "DFTD", "Tasmanian devil", "Tasmanian ecology", "devil facial tumor disease", "wildlife disease management", "pathology", and "vaccine". Criteria including ecological consequences, cost of implementation, and time needed to implement are used to examine the proposed control strategies and to propose an optimal management approach.

Though many strategies have been proposed, this thesis will focus on the three main methods suggested throughout the literature: selective culling, implementation of assurance colonies, and vaccine development. It will also summarize the research challenges that will need to be addressed going forward with devil conservation. Two other wildlife disease and management cases are included as supporting examples: selective culling among white tail deer to combat chronic wasting disease, and selective culling among European badgers to combat bovine tuberculosis.

After evaluating the literature based on the aforementioned criteria, this paper will provide an educated recommendation for Tasmanian devil and DFTD management.

RESULTS:

Selective culling

The objective of direct population manipulation is usually to reduce contact between infected and healthy individuals [16]. This approach has been employed in managing white-tailed deer and European badgers for chronic wasting disease (CWD) and bovine tuberculosis (TB), respectively. However, these culling programs experienced limited success.

While CWD has density-dependent transmission, meaning that transmission increases with population size in a given area, DFTD is frequency-dependent, meaning that transmission increases with contact between healthy and infected individuals. However, CWD management studies have been cited in the DFTD literature as a relevant example of host-culling. The white-tailed deer study conducted by Gideon Wasserberg et al. used mathematical models to find that host-culling, in this case, not only resulted in disease and host extinction; it also shortened time to extinction by 60-70 years [15].

Another study cited in DFTD literature is the case of host-culling among European badgers to combat TB among cattle in England. This management practice had been employed for three decades prior to the cited research, despite public controversy. While the study found that there was 19% decrease in the incidence of bovine tuberculosis among cattle in areas that underwent badger culling, there was an overall increase in incidence among neighboring cattle populations that did not undergo badger culling. Researchers suggest this is because the culling strategy interrupted the badgers' territorial organization in areas of artificially reduced population, leading the animals to interact more with neighboring populations, thus transmitting the disease to potentially healthy individuals in areas not undergoing culling [3].

Several aspects of DFTD and Tasmanian devil ecology suggest that host culling may be an appropriate means of control. Since infected devils are easily identified once they have become infectious, trapping them is feasible. DFTD is also a single-host disease, so maintaining a reservoir population for any other species would not be necessary [9]. However, in order for selective removal to even be effective, it would have to be done continuously, which would be very demanding of human and monetary capital. Also, it is widely believed in the wildlife conservation community that any kind of culling of an endangered species is unacceptable [(1, 9)]. According to research done by Shelly Lachish et al., selective culling of devils may simply substitute for disease-induced mortality [(9)]. Furthermore, it is important to consider the potentially detrimental effects culling would have on the Tasmanian devil social structure. If culling among European badgers lead to a geographical expansion of bovine tuberculosis, could the same happen for the socially similar Tasmanian devils and DFTD [(3)]?

One suggestion, though it has not yet been employed, is adult removal in infected populations. That is, in diseased populations, adults could be removed after weaning their young. Since infection is most common at 1-2 years old, the newborn devils would be disease-free. Again, it is important to keep in mind that reducing population density of an endangered species, especially when it is done to control a *frequency-dependent* disease will likely be ineffective[7, 9].

Assurance populations

Captive and wild assurance populations have been in place for years to isolate healthy devils from infected individuals. However, captive colonies have had a track record of low reproductive output [7, 12]. Such populations on their own would not fulfill the conservation goals for the species. Researchers Mena Jones and Peter Jarman suggest utilizing island corridors and maintaining 95% genetic diversity for the species [7]. Populations should remain in place until one of three events occurs: "1.) the evolution of resistance…; 2.) the development of a field-deliverable vaccine; or 3.) extinction of wild Tasmanian devils," which would result in the extinction of DFTD as well, at which point individuals from assurance populations could be released onto the mainland again [7].

Though island corridors seem to be a wise option for devil conservation, it is important to take several other important ecological factors into consideration. There are 330 offshore islands near Tasmania, and most are too small or have too few resources to maintain the number of devils necessary to keep the aforementioned 95% genetic diversity [7]. It may be possible to spread the necessary population across several islands, but existing island ecologies must be taken into consideration. As apex predators, Tasmanian devils may outcompete existing mesopredators on island corridors and have a deleterious effect on the island's (or islands') prey species [7].

Vaccine development

Much of the literature included in this review mentioned the need for vaccine development to combat DFTD [(2, 4, 5, 7, 9, 11)]. However, urgency is the main component of conservation efforts. Developing and testing a vaccine would take years and extensive funding from the Australian government or other sources, which as of yet has been lacking [(9, 12)]. Because DFTD is spreading so quickly, assurance colonies would be necessary while a field-deliverable vaccine is in development [(9)].

Some vaccine research has offered promising results. According to a field study by A. Kreiss et al. (2015), killed cell preparations may be an immunization option for devils. This option is similar to flu vaccines for humans. In order to build an immunity, devils are subjected to a dose of dead DFTD cells.

DISCUSSION:

Selective culling of an endangered species suffering massive population losses is probably ill-advised. As seen in the case of CWD control through culling of white-tailed deer, there is a chance that removal would simply compensate for disease mortality. The effect among Tasmanian devils would likely be more detrimental because of their small population and the fact that DFTD is frequency- dependent rather than density-dependent like CWD. The fact that effective culling would have to be done continuously makes it an economically infeasible option.

Assurance populations are a viable and ecologically sound option, for the most part. Research has suggested the use of island corridors for assurance populations for Tasmanian devils. This option would be costly and it would require a lot of research to find one or, more likely, several suitable islands. Rotating assurance population individuals between the islands would be time-intensive, as well, but it would be beneficial for maintaining genetic diversity.

Vaccine development is the most promising ultimate management solution for DFTD. Eradication of the disease in the wild is likely the most effective way to conserve Tasmanian devils in the long run. However, vaccine development will require significant funding from the Australian government and other organizations, which as of yet has been lacking. It would also be very time-consuming. While vaccine development is necessary, another management option would need to be used in tandem to control DFTD in the short term. This option will be addressed in the Conclusion section.

CONCLUSION:

Based on the literature included herein, it appears that the best management option for Devil Facial Tumor Disease is the establishment of insurance populations on offshore islands while researchers work on a vaccine. The insurance populations will likely need to be spread out over several islands to be large enough to maintain 95% genetic diversity. The populations will need to be kept in place until one of three events occurs: the development of a field-deliverable vaccine; the natural evolution of DFTD resistance among devils; or the extinction of Tasmanian devils and DFTD on the mainland, at which point the insurance populations would be reintroduced.

Lastly, it is important to note that much is left to be learned about DFTD. Due to a lack of governmental funding, researchers have not been granted the time to perform proper studies regarding the disease front. Michael Bode and his research team noted that a lack of funding contributed to a lack of time and imperfect data collection when attempting to locate the disease's geographical boundaries, and lack of funding has been a problem throughout DFTD's history [1, 2, 5, 8]. After obtaining sufficient funding, researchers should focus investigate factors of disease's transmission, such as the super-spreader hypothesis, which says that certain individuals (usually highly sexually active male devils) may be a root cause for DFTD's rapid spread [1, 9]. Researchers should also use funding to learn more about DFTD's latent period. At this point, devils are only diagnosable once they are presenting with tumors and are infectious. If researchers can determine how to diagnose DFTD before that point, selective culling may become a more viable option [1, 9, 15].

According to the literature included herein, the establishment of insurance populations and vaccine development seem to be the most ecologically sound options for Tasmanian devil conservation. However, careful island selection, obtainment of sufficient funding from the Australian government, and further investigation into DFTD transmission dynamics and latency will be vital to the effort of devil conservation, as well.

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Appendix

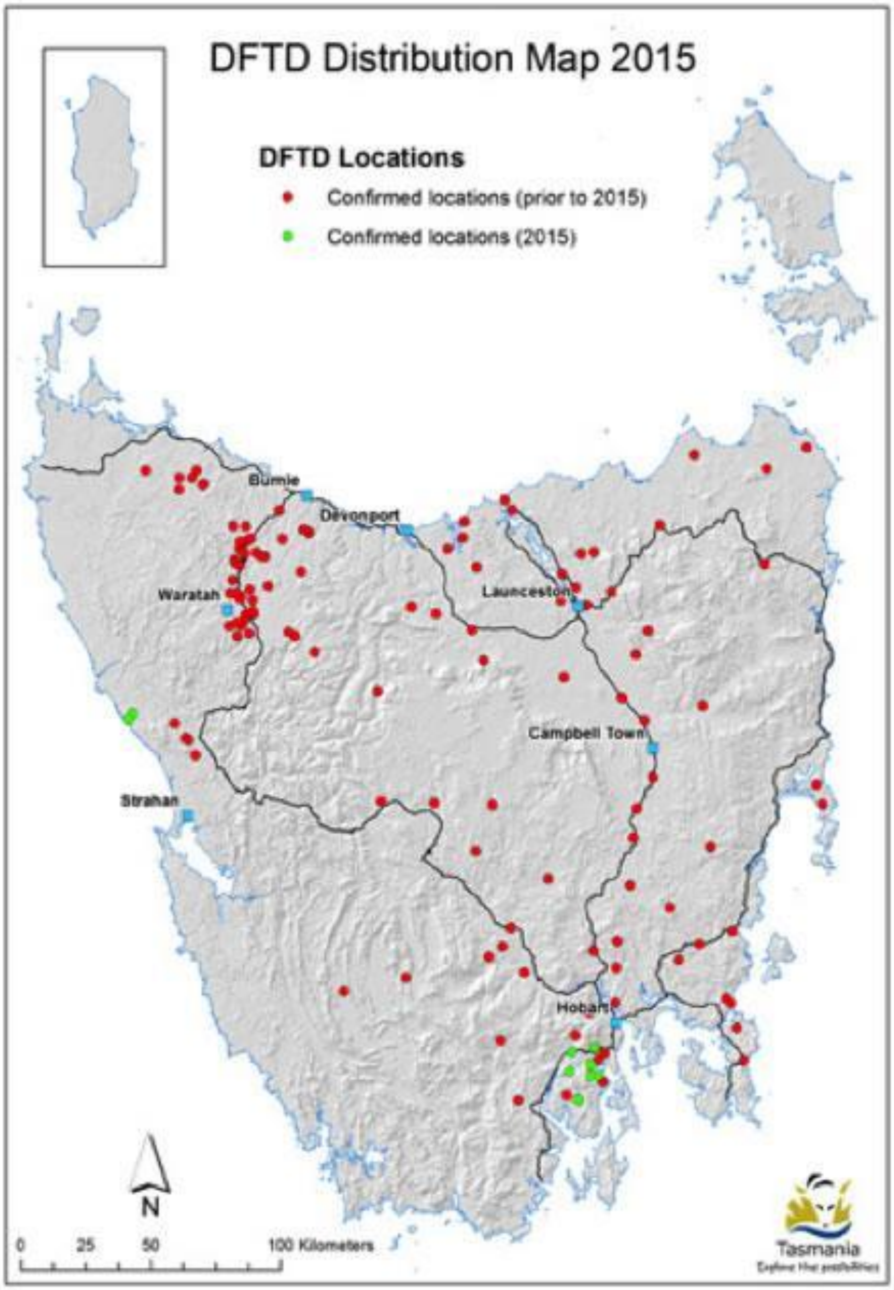

Figure 1: Devil Facial Tumor Disease (DFTD) distribution map. The first cases of disease were confirmed in the northeast corner of Tasmania. As of 2015, no confirmed cases have been reported in the northwest area of the island. Source: Devil Ark, a Tasmanian devil research and conservation organization.

Figure 2: A healthy, adult Tasmanian devil. Source: https://www.steveparish-natureconnect.com.au/nature-centre/king-of-the-dasyurids-the-tasmanian-devil/

Figure 3: An infected adult Tasmanian devil with clinical signs of Devil Facial Tumor Disease. Source: http://discovermagazine.com/2014/may/13-the-immortal-devil